Seattle's Central Waterfront Plan

Central Waterfront Plan Background Report

Natural Conditions

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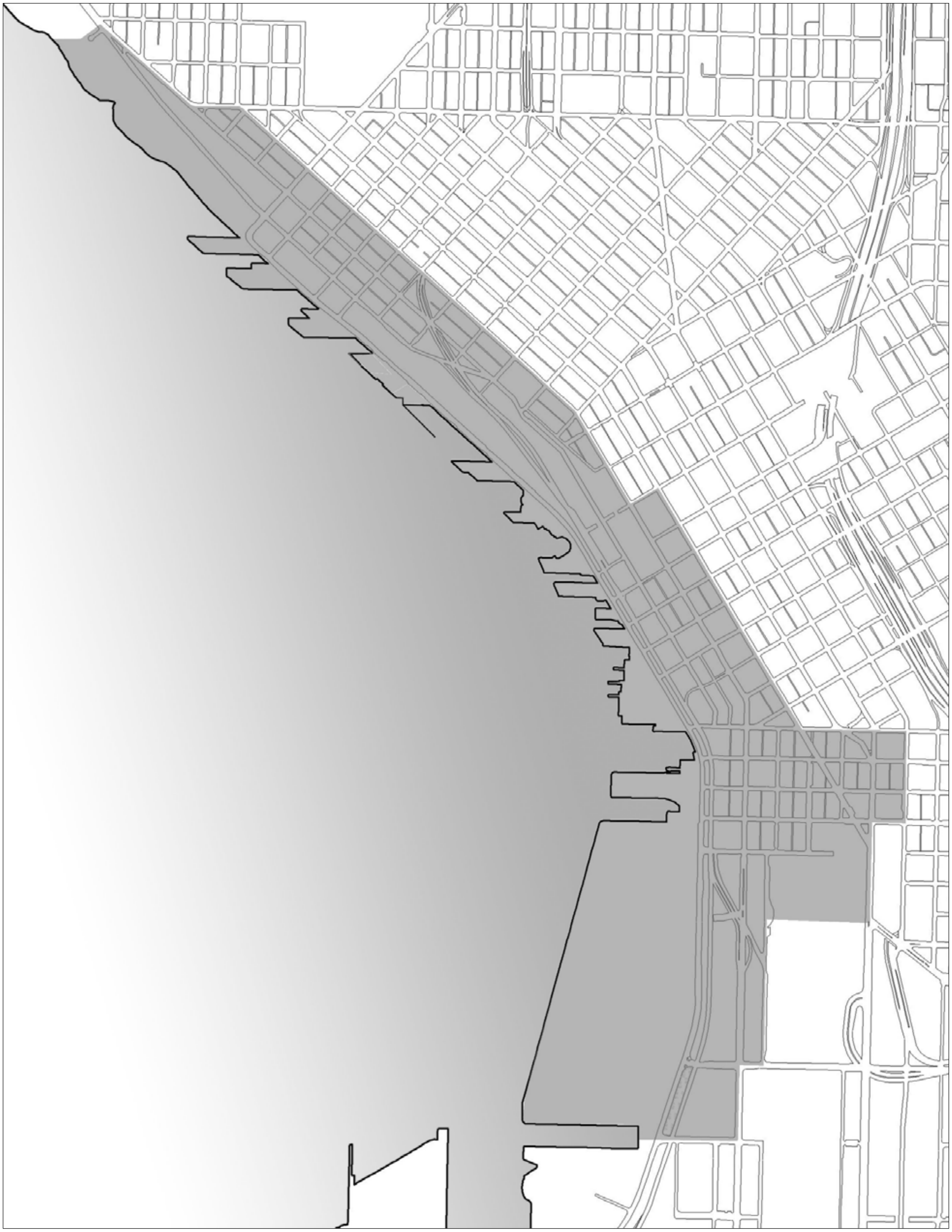
Department of Planning and Development
City of Seattle, Greg Nickels, Mayor
city design

Seattle's Central Waterfront Plan: Study Area



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Overview

Seattle's Central Waterfront is the place where two worlds come together—the surface world of dense urban development and human activity hugging the hillsides, and the hidden, underwater world of Elliott Bay that supports the equally complex activities of its diverse marine population. While the shoreline is often regarded as a hard edge separating the two worlds, in reality it is an area of transition, where the surface and water worlds interact.

Efforts by Seattle's early settlers to adapt the shoreline environment to the needs of the pioneer city dramatically altered natural conditions. Hilltops were regarded and tidelands filled, reshaping the shoreline to accommodate the functions of a bustling port and industrial center. At a time when most of the region was wilderness and natural resources plentiful, there was little regard for the environmental consequences of these actions.

Today, addressing the changing functions of the Central Waterfront at a time of increased environmental awareness and concern provides the opportunity to rectify some of the environmental damage of these past actions and to promote a more ecologically sound environment in the future.

Topography and Bathymetry

Seattle is sited on the eastern edge of Puget Sound in a topographic feature knows as the Puget Lowland. The Puget Lowland is structurally a continuation of the Puget Sound Trough, bounded by the Cascade Mountains on the east and the Olympic Mountains on the west. The overall geology of the area is young material downwarping between the Cascade and Olympic Mountains.

Both the topography and geology of the Puget Lowlands reflect long periods of glacial activity. The last glacial period, known as the Vashon Glaciation, occurred approximately 15,000 years ago. This glaciation, along with earlier ice advances, shaped the hills, ridges, valleys and troughs of the Puget Lowland areas into elongated forms. These land forms above and below sea level generally run north-south, corresponding with the direction of the glaciers' advance and retreat.

The hills and valleys of the Seattle area have weathered over time and erosion has occurred. Over the millennia, the Duwamish River deposited sediments where it feeds into Elliott Bay, creating vast tide flats. In recent history, the greatest modifications have occurred through urbanization. In the early 1800's the tide flats extended eastward to the base of Beacon Hill, and Harbor Island did not exist. The southern portion of Pioneer Square, the area that is now Terminal 46, and the Duwamish industrial area were all part of an expansive mudflat—unbuildable due to inundation by tidewaters. In order to

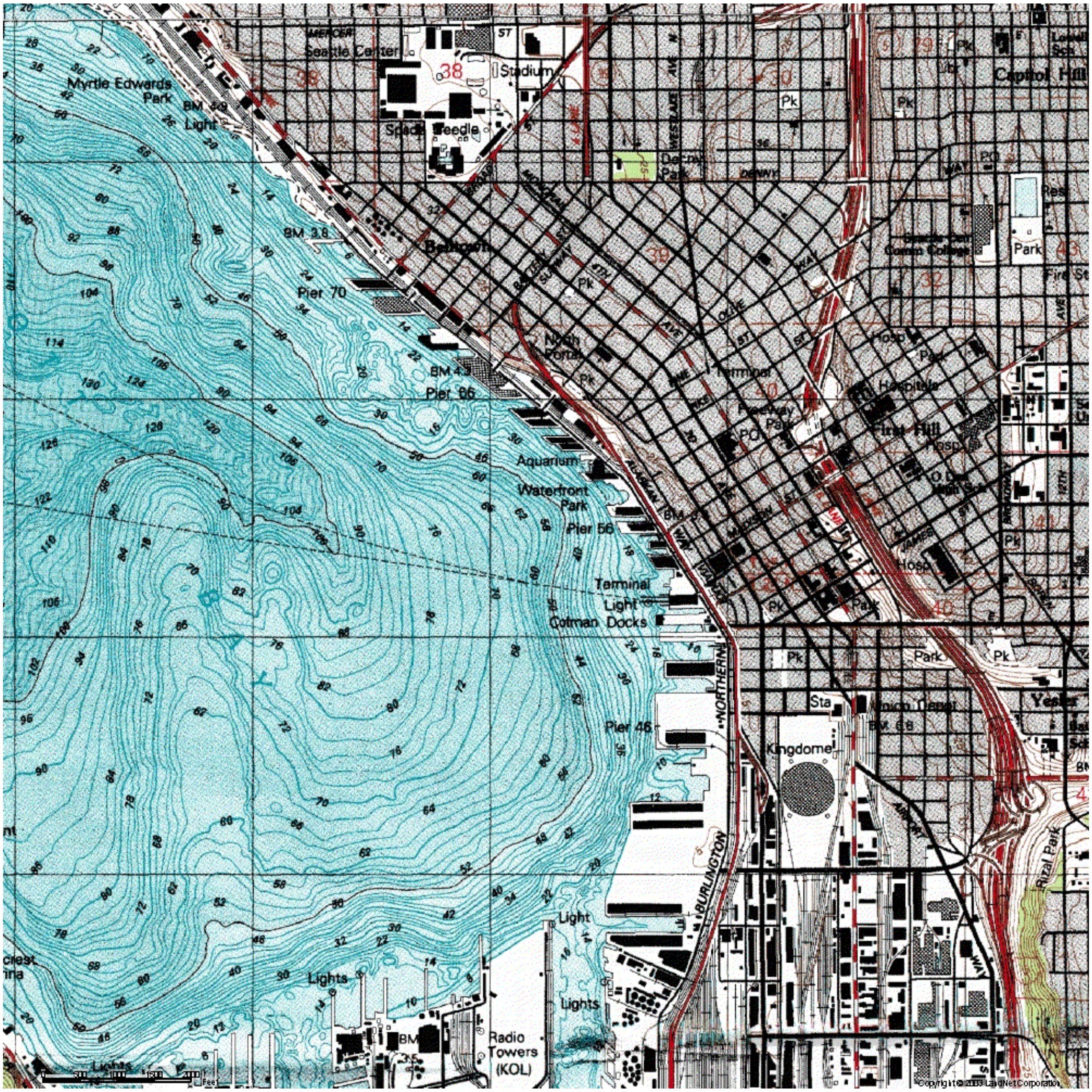

Figure 1. Topography and Bathymetry Map
(Source: LandVoyage Unlimited)

increase buildable land, in the late 19th and early 20th centuries, hilltops were regarded to level numerous ravines and fill the tideflats. The result of these massive engineering efforts was the creation of the existing shoreline and Harbor Island, the channeling of the Duwamish River, and the draining and filling of the tideflats.

Historically, topography has had a significant influence on conditions in the Central Waterfront, and will likely continue to affect the future urban form and character of the area. The glacially sculpted topography/bathymetry created the deep water conditions conducive to Seattle's early development as a port. In an area of irregular topography, the flat land created through the filling of tidelands allowed for commercial and industrial expansion. The thin stretch of beach and shallows at the base of the bluffs rising from the bay was filled, creating artificial land to accommodate the city's earliest transportation corridor and urban development. The rapid depth of the bay, which drops quickly to 80 – 100 feet and deeper, also influenced the angled, sawtooth pattern of the existing piers—the angles increasing wharf frontage while allowing pilings to remain in shallower water. (Figure *1*.)

Topographic conditions have also shaped development patterns defining the relationship between the Central Waterfront and neighboring areas. Where topography did not present a barrier, waterfront-related activities spilled over into adjacent upland areas. Elsewhere, the high bluffs along the waterfront's edge interrupted connections with the uplands and separated the area from the rest of downtown.

Seismic Conditions

Related to Seattle's geology and topography is the seismic activity of the area. Seattle is sited in one of the most seismically active areas in the world. Almost 80 percent of the world's earthquakes occur along a Circum-Pacific Seismic Belt which extends along the west coast of North America. This belt is called the "ring of fire" because it is also the location of the majority of the world's volcanoes.

The actual seismic risk associated with an area is a function of the historical patterns of earthquakes, the magnitude of these earthquakes, and the geology of the area. Seattle has a history of earthquakes, the majority of which have been small tremors. However, Seattle's most recent seismic activity was the Nisqually earthquake in February, 2001, which directly affected the Central Waterfront with damage to the Alaskan Way Viaduct and numerous upland buildings. The Central Waterfront area is especially susceptible to earthquake damage because of construction on unstable soils—essentially the artificial fill made up of ship ballast, saw mill wastes, and earth from numerous upland regrade projects deposited on what previously had been submerged land or tide flats. The deep-seated vibrations of earthquakes can consolidate these soils and damage buildings.

All new buildings in the area must meet special earthquake regulations set in the Uniform Building Code (UBC). The UBC uses a five zone system, from Zone 0—no damage—to Zone 4—major damage. These zones are based on a scale that considers past earthquake activity in an area, as well as proximity to known major fault systems, and descries expected intensities of seismic activity by the degree of damage caused to buildings. The Seattle area is rated in the UBC as a Zone 3—major damage. For comparison, the higher classification, Zone 4, is found primarily in sections of California close to the San Andreas Fault.

The topography, geology and seismic conditions downtown combine to affect the cost of construction. Extraordinary consideration must be made in developing structural systems to meet potential seismic forces, particularly in areas with unstable soils, like the Central Waterfront. Most of these problems are not insurmountable, just more expensive.

Habitat

Modification of Elliott Bay along the Central Waterfront has resulted in the total elimination of natural habitat characteristics along the shoreline extending from the mouth of the Duwamish River to the north side of the bay. Sawdust, ballast, fill from regrade projects, remnants of roads and rail trestles, and construction materials all were used to fill in the soft marshlands that bordered Elliott Bay to make way of r industry and transportation. As the shoreline was filled, eel grass for herring and tidelands for shellfish were eliminated, and the role of Elliott Bay as a site for migrating salmon began to decline. Contamination of Elliott Bay occurred as a result of the erosion and sedimentation associated with grading projects and with sewage outfall before appropriate infrastructure was built. Along Elliott bay, the built shoreline was bounded and held in place by large-scale public works that had evolved from a rail trestle structure into a road and more permanent seawall. Extending further out from the seawall to deeper water was a series of timber piers, so that the shoreline armature became an repetitive, tooth-like pattern of pile structures. Where the natural shoreline supported a rich diversity of plants and animals in a series of gradual transitions from land to water, the built shoreline made a hard and abrupt transition –less susceptible to the dynamic forces of the waterfront environment but also less productive as a habitat for plants and animals.[1] Filling of intertidal beaches together with construction of the seawall and piers has resulted in steep hard substrate from above the high tide line elevations to shallow subtidal elevations. This absence of natural slopes and substrates over several miles of shoreline creates a need and an opportunity to restore natural habitat functions to an urban shoreline of considerable value to the anadromous salmonid and other biological resources.[2]

Plants

The shoreline and bottom sediment support very few marine plants because most of the area has been modified over the last 50 to 100 years by dredging, filling, and pier construction. However, kelp and seaweed do exist in this part of Elliott Bay. The primary vegetation on land is the landscaping provided by the City and private property owners, including street trees, plants and shrubbery in potted containers.

[1] March 2002, Alaskan Way Viaduct and Seawall Project Urban Design Assessment, by ROMA Design Group for Washington State Department of Transportation and the City of Seattle.

[2] April 22, 2003, Technical Memorandum, Alaskan Way Viaduct Seattle Shoreline Habitat Restoration Opportunities, Parametrix, Inc., NOAA Fisheries, and Washington State Dept. Fish and Game.

Animals and Marine Life

General Conditions

The present environment along the Central Waterfront is almost entirely artificial, and is comprised of pilings, stone riprap and dredged silty bottoms. The pilings, riprap, and soft muddy bottom each support different forms of marine life.

The piling habitat is extremely variable, depending upon the age of the pilings and the activity in and near them. In general, the pilings support anemones, alga, barnacles, starfish, mollusks, crustaceans, and the marine terredoe, which feasts on the wood, if stringent protective measures are not taken. The composition of the piling community species varies with elevation as a result of tidal inundation duration and, to a lesser degree, aspect in relation to solar exposure and predominant tidal currents. The algal community exists where hard substrate provides attachment sites for holdfasts, which are generally along the seawall. The riprap provides a sheltered habitat for blennies, sculpins, other fish, and coon-striped shrimp. A wide variety of fish, such as perch, rockfish, Pollack, sculpins, and blennies inhabit the riprap and pilings.

The soft bottom supports rockfish, cod, flatfish, bivalve mollusks, and polycheate worms. The mollusks are not of commercial value, but do provide food for fish. No rare, endangered, or unique species have been found along the Central Waterfront. The pelagic community (animals living in the water column) include fish, jelly fish, and various planktonic microorganisms on which many aquatic organisms feed. Upper layers of the water column are used by herring, anchovy, and salmon as they migrate from the Duwamish River in the spring. Juvenile steelhead trout are also released into the Duwamish, but rarely are found along the waterfront. Altogether, the presence of about 80 species of fish has been documented in Elliott Bay, with dominant species including English and rock sole, Pacific tomcod, shiner and striped seaperch, tubesnout, and ratfish. The Duwamish River anadromous salmonid populations are of greatest interest in terms of potential impact from waterfront development.

Eight species of anadromous salmonids use the Duwamish Estuary, Green River, and Elliott Bay during spring migrations from April to June. Chinook and coho salmon and steelhead are common, while pink and sockeye salmon, sea-run cutthroat trout, and bull trout are much less common. Small runs of chum salmon also occur, with larger runs in recent years.

There are a few types of birds that live on the waterfront. Urban birds, such as pigeons and house sparrows, nest and feed there. Water-oriented birds like gulls and western grebes use the ships and piers as resting areas. Small rodents also inhabit the area. Other shoreline bird species may appear from time to time, but do not stay on a year-round basis. Waterfowl such as white-winged scoter, scaup, and Canada geese are infrequently seen.

Nearshore Environment

The nearshore environment in Puget Sound possesses an extremely productive and dynamic ecosystem. The marine nearshore environment encompasses the area from upland bluffs, banks and beaches, and the lower limit zone, which varies with season and climate conditions. The lower limit of the photic zone is generally defined at approximately 100 feet below the Mean Lower Low Water (MLLW) line. The marine nearshore environment within Seattle can be divided into four areas: Elliott Bay, Shillshole Bay, Duwamish Estuary, and other nearshore areas, with the Central Waterfront included in the Elliott Bay environment.

Human alteration to the nearshore environment has been occurring in Seattle from at least the mid to late 1800's. These activities included extensive filling within Elliott Bay and other areas to increase the city's land base, bank hardening along a significant portion of the shoreline for railroad right-of-way and for property protection, and construction of commercial piers and marinas. Most of the intertidal habitat of the eastern shoreline of Elliott Bay was filled and the shoreline bulkheaded to create the present Central Waterfront. The combination of these historic habitat losses and the cumulative impacts of urban development have resulted in major changes to the shoreline environment and the marine nearshore ecosystem. Overall, both the living space and the sources of food production for young salmon have been greatly reduced, and what remains is frequently highly altered. While many juvenile Chinook appear to follow the nearshore environment as they migrate into Elliott Bay and Puget Sound, the altered shoreline provides limited useful habitat for producing food sources for young salmon.

Relatively little is known about the direct effects of urban development and other human impacts on the migration, growth, survival, and habitat of Chinook salmon in the marine nearshore areas of Seattle. However, it is known that bulkheading, bank armoring, and other human activities within shoreline areas have affected many physical processes including sediment production and transport, and that these processes are important for forming and maintaining habitat for juvenile Chinook salmon in the marine nearshore and estuary areas.

Historically, Elliott Bay consisted of extensive intertidal mud and sand flats and vegetated wetlands bordered by steep banks. Development of the existing Downtown business and industrial districts has resulted in extensive filling, dredging, and grading along the shoreline. Currently, the shoreline along Elliott Bay is characterized by seawalls, bulkheads, and over water structures. In Elliott Bay, overwater structures are the predominant shoreline modification, occupying over 65 percent of the bay shore. Most of the shoreline areas of Elliott Bay have been altered, with water depths dropping rapidly to 80 feet and deeper. In addition, several combined sewer outfalls (CSO) operated by the City of Seattle and King County discharge into Elliott Bay. The mouth of the Duwamish/Green River is located at the southern extent of Elliott Bay.

Overwater structures affect interidal and shallow subtidal organisms and habitats by casting shade, as well as by causing in wave action, climate, and substrate. These physical changes alter plant communities, such as kelp and eelgrass beds, and change nearshore food webs. Because they migrate along the nearshore in shallow water, juvenile ocean-type Chinook and Chum salmon are believed to be vulnerable to docks and overwater structures during their emigration to the Pacific Ocean. Modifications to migrating behavior caused by overwater structures could also make salmonids more susceptible to predators. However, fish predators appear to be rare under piers, and several studies have concluded that lists of "potential predators" areas that had been associated with these structures in marine areas are questionable and have been propagated through literatures predominantly without validation.[3] Overall, there is a lack of quantitative data to indicate that behavioral responses to overwater structures truly decrease survival of emigrating juvenile salmonids. Quantitative and experimental data are needed to assess the risk posed by these structures.

While many biologists believe that piers are potential barriers to young salmon, studies in the Duwamish River and Elliott Bay, as well as other locations, indicate this is not the case.[4] Newer concrete pile-supported piers typically require fewer piles and allow more light penetration than the typical older piers supported by treated wood piles. Pier aprons include both those parallel the shoreline (newer style) and those perpendicular to the shoreline (older style). Most likely the perpendicular piers are more of an interruption to migration than those parallel to the shoreline. Studies concluded that delays in migration occur when juveniles are confronted with conflicts in preferences, which presumably occur when piers are encountered.[5]

Armoring of the shorelines of Elliot Bay has reduced shoreline and bluff erosion, reducing sediment inputs that are important to the formation and maintenance of nearshore habitats. Along the Central Waterfront, bank armoring has essentially eliminated habitat areas provided by beaches and sand spits. Very few studies have evaluated the effects of armoring on fish and other aquatic resources in the study area.

Habitat Improvement

Intertidal habitat along the Central Waterfront is important because juvenile Chinook and chum salmon of the size that migrate along the Seattle waterfront from the Green/ Duwamish River have specific habitat preferences that are not met by existing waterfront characteristics. These juveniles commonly remain in close proximity to shoreline structures (beach, bulkheads, piers, etc.) and within 1-2 m of the water surface. The fish appear to prefer gently sloping mud-cobble beaches. They

[3] Factors Affecting Chinook Populations, Background Report, City of Seattle, June 2000; prepared by Parametrix Inc., Natural Resources Consultants, Inc., Cedar River Associate, p. 70.

[4] Ibid., p.69.

[5] Factors Affecting Chinook Populations, Background Report, City of Seattle, June 2000; prepared by Parametrix Inc., Natural Resources Consultants, Inc., Cedar River Associate, p. 70.

commonly prey on epibenthic crustaceans during their rearing migration along this shallow water habitat. Thus, feeding at the bottom in shallow water they are susceptible to the forces of substantial waves and appear to avoid areas of substantial wave of current energy. Therefore, recommended mitigation habitat would attempt to reproduce both the shallow water characteristics apparently preferred by small juveniles and the sheltered conditions that make this habitat more functional for their needs.[6]

There are a number of open areas along the existing waterfront where the shoreline is not committed to commercial uses. These open spaces offer limited but substantial opportunities to restore natural habitat functions through an approach that would restore some of the shallow water functions needed by young salmon as they migrate along the Seattle waterfront. Because of the substantial length of shoreline involved, it is desirable to develop several habitat restoration areas that would help to restore a connected corridor.[7] The following is a brief summary of habitat restoration opportunities identified for consideration as part of the Alaskan Way Viaduct environmental evaluation, which are shown in Figure 2.

1. **Pier 48.** One habitat mitigation site is located between the Washington Street Public Boat Landing and Colman Dock, where large rocky substrate has been placed and acts as a site for algal community development and interstitial cover for fish and invertebrates. Develop an intertidal beach complex that is protected by an arch shaped extension roughly following the Pier 48 alignment or possible other alignment with redevelopment of Colman Dock. Could involve removal of Pier 48 and construction of new beach.
2. **Waterfront Park.** Develop an intertidal beach along the areas immediately adjacent to the Waterfront Park pier.
3. **Seattle Aquarium.** Develop an intertidal beach along the shoreline between the Seattle Aquarium and Pier 63.
4. **Pier 62/63.** Develop a new intertidal beach habitat along most of the shoreline portions of the piers. Involves removal of piles and decking along most of seawall to expose shoreline, while retaining narrow access connection to Piers.
5. **Pier 70/Myrtle Edwards Park Shoreline.** Produce new protected intertidal habitat along a substantial length of shoreline north of Pier 70 where it will not conflict with existing shoreline uses. Employ a detached offshore breakwater concept to protect shoreline habitat from wind waves and vessel wakes that

[6] April 22, 2003, Technical Memorandum, Alaskan Way Viaduct Seattle Shoreline Habitat Restoration Opportunities, Parametrix, Inc., NOAA Fisheries, and Washington State Dept. Fish and Game.
[7] April 22, 2003, Technical Memorandum, Alaskan Way Viaduct Seattle Shoreline Habitat Restoration Opportunities, Parametrix, Inc., NOAA Fisheries, and Washington State Dept. Fish and Game.

(Graphic to come)

Figure 2. Habitat Restoration Opportunities

commonly reach this shoreline with considerable force. The small beach cove at the north end of Myrtle Edwards Park (or between the City's park and the Port of Seattle's Elliott Bay Park) has been the subject of previous beach restoration studies. The existing beach could be extended inland and to the south behind the existing rip-rap to expand the shallow intertidal area of the park. Such action would support habitat diversity. Estimated cost of such a project range from $200,000 to $1 million. The development of the Olympic Sculpture Park is proposed to incorporate some restoration of the shoreline between Pier 70 and Bay Street.

6. **Seawall Reconstruction.** As part of seawall replacement , explore opportunities to provide the essential habitat characteristics along the face of the seawall where replacement may not allow development of fill providing sloping intertidal habitat.

Climate

The Central Waterfront study area is characterized by equable temperatures, a pronounced rainy season, and considerable cloudiness. The Cascades of the east and the Pacific Ocean to the west combine to modify temperature extremes. Usually, the daytime winter temperatures reach the mid-40's and the daytime summer temperatures remain in the mid-70's. Seasonal low temperatures range from the 30's to the low 50's.

Rainfall occurs primarily (75 percent) from October through March, totaling 40 inches in an average year, as compared with San Francisco at 23 inches a year, New York at 42 inches per year, Miami at 60 inches a year, and Chicago at 33 inches a year. Snowfall is extremely rare, and when it does fall, it usually melts quickly.

Clear days normally correspond with the warmer days of July and August, averaging ten per month. The other months normally see three to five each.

Wind is usually light during the night, picking up to speeds of 15 mph during the afternoon. The usual direction is from the southwest, switching, switching to the northwesterly direction during the simmer months.

Marine Environment

Currents in Elliott Bay are weak and dominated by tidal flux, especially in the outer bay, and by Duwamish River effluent in the inner bay. Currents generally move in a counterclockwise direction, and the Duwamish River plume appears almost continually along the north side of the bay.

The water circulation in Elliott Bay results from the interaction of tides, winds, and discharge from the Duwamish River. Because of the sea water's relative density, water discharge from the Duwamish River forms a surface layer over the sea water of Elliott Bay. This layer ends to be retained along the waterfront due to prevailing winds. Tidal action carries it out of the Bay for gradual assimilation into the saline sea water. The piers and structures retard the water flow and mixing, thus retaining the near-surface fresh water. An oil film, caused by ferries and ships, sometimes accumulates on the water surface, particularly in the immediate vicinity of the ferry terminal. At times, floating debris accumulates along the shoreline.

Water Quality

Water quality in Elliott Bay is potentially adversely affected by discharges from public and private stormwater drains, combined sewer outfalls (CSOs), and industrial discharges and sediment contamination. Areas draining into the study area are highlighted in Figure 3. The largest current discharges of stormwater occur at the major combined sewer outfalls. These outfalls discharge combined stormwater and sewage when the capacity of the system is exceeded during major storm events. There are numerous other separated stormwater outfalls that do not carry sewage during storm events.

The shoreline waters of Elliott Bay are often in violation of State water quality standards for fecal coliforms and dissolved oxygen and exceed federal standards for levels of oil and grease. Shellfish populations in Elliott Bay are presently not harvested because of high fecal coliform counts and industrial effluent inputs. Toxic metals and chemicals may be a problem in certain areas. Problems are in part due to combined sewer overflows (CSO) into the Bay during storms.

Pursuant to the Clean Water Act, the Duwamish River and Elliott Bay are on he state's 303(d) list. Initial characterizations indicate state water quality and sediment standards are exceeded for more than 30 toxic compounds and eight metals. The sediment standards serve as a basis for identifying areas that will require further study using biological screening methods. The City of Seattle, together with King County, the Port of Seattle, and Boeing are entering into an agreement with EPA to determine what areas would be priority for cleanup and what technologies are feasible.

Sewage Discharges

Fifty-five CSOs and storm drains discharge treated and untreated effluents and stormwater runoff into the Duwamish Estuary and Elliott Bay, although mean annual discharges have decreased from 2.4 billion gallons per year (1981-1988) to a current 1.6 billion gallons per year. Thirty-five CSOs and storm drains discharge to the shore of Elliott Bay and the East and West Waterways. Combined Sewer Overflows (CSOs) discharge organic and inorganic substances from untreated sewage during stormwater overflow, although about 90 percent of discharges consist of stormwater. (Figure 4.)

King County (King County 1999a) recently conducted a water quality assessment of combined sewer overflows (CSO) impacts in the Duwamish River and Elliott Bay. This assessment identified minimal risks to aquatic life from chemicals in the water column, no risks to juvenile salmon from direct exposure to chemicals in the water, and no risks to salmon smolt from consuming amphipods in the Duwamish Estuary. The study found that risk to aquatic life in the water column is low to none. The King County CSO assessment did find potential risks to the benthic community from chemicals in the sediments and localized areas of risk from sedimentation and scouring.

Graphic to come

Figure 3. Drainage into Study Area

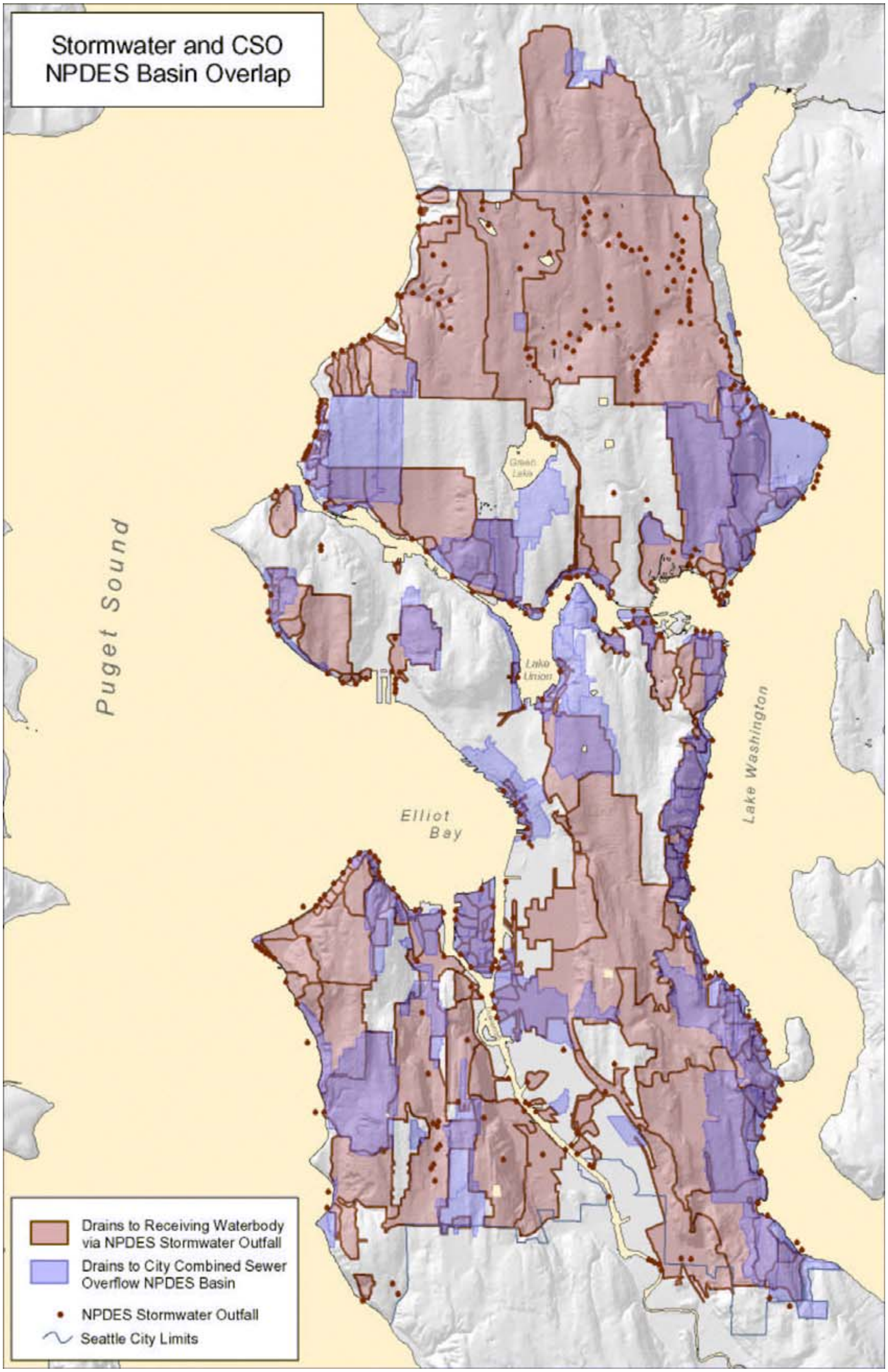

Figure 4. CSO Discharge

Sediment Contamination

Numerous studies investigating sediment contamination in Elliott Bay and the Duwamish Estuary indicate that PCBs, PAHs, metals, and other organic compounds, pesticides, and TBT are present in river and bay sediments at concentrations above state sediment quality standards. Contaminants have entered the bay and river in a variety of ways, including spillage during product shipping and handling, direct disposal or discharge, contaminated groundwater discharge, surface water runoff, stormwater and CSO discharge, or contaminated soil erosion.

Along the Elliott Bay waterfront, studies have identified mercury, silver, lead, zinc, and PAHs at concentrations exceeding CSL screening guidelines. Mercury exceeded its respective CSL throughout the waterfront area between Piers 46 and 63, except in areas that have been capped (Piers 51 and 53 to 55). The remaining metals and PAHs exceed their respective CSL screening guidelines sporadically, often between piers and slips.

The Duwamish River transports fine material--sediments of primarily sand, silt, and clay—in a freshwater plume emptying into Elliott Bay. Sediments return from Elliott Bay to the Duwamish as a near-bottom sediment load contained in the salt water wedge. Most of the Elliott Bay waterfront between Pier 91 and Duwamish Head has no appreciable net shore drift of sediments because of shoreline development. Water depth and the obstruction of piers preclude any significant longshore transport. At present, the only source of sediment for shore drift is erosion of undefended fill material.

Tidal Characteristics

Elliott Bay is subject to considerable difference between high and low tides. The mean difference is 7.6 feet. The difference between high/high tide and low/low tide is 11.3 feet and the difference between the extreme high and low tides registers 19.3 feet. The mean average high tide comes within 8.4 feet of the level of Alaskan Way, while the average mean low tide is 16.0 feet below the level of Alaskan Way.

These tidal conditions have implications on the types of opportunities that can be provided to increase public access and contact with the water. Locations where tidal differences are significant may be less conducive to solutions like floats or embankments that descent to provide access to the water level.

Issues

To be developed

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